

## CLAIMS

We claim:

1. Method for the production of caps with a heat shrinkable skirt comprising:

(a) an extrusion step in which an extruded tube is formed of a thermoplastic material by extrusion using a die supplied by an extruder operating at temperature  $T_0$  chosen as a function of the softening temperature or the melting temperature  $T_f$  of the thermoplastic material, the die having a diameter  $D_0$ , a slit width or thickness  $E_0$  and a corresponding section with area  $S_0$ ,

(b) a radial expansion step of the extruded tube to form a radially expanded tube with diameter  $D_2$ , thickness  $E_2$  and corresponding section with area  $S_2$ , due to a radial expansion device,

(c) a chopping step in which the expanded tube is chopped into portions of tube with an appropriate length, the radially expanded tube pulled by an axial tension means,

(d) a step to form tube portions in which each portion of tube is placed on a typically tapered conformation mandrel and is formed by heat shrinkage to form a heat-shrunk cap blank, one head also typically being assembled to the blank or formed from the blank, so as to obtain a cap or a heat shrinkable cap provided with the head and a skirt, and typically capable of receiving printing, and characterized in that a drawing step is included in which the extruded tube is drawn in the axial direction, at the exit from the die of the extruder between the extrusion step a) and the expansion step b), so as to obtain an axially drawn tube with diameter  $D_1$  typically less than  $D_0$  and  $D_2$ , with thickness  $E_1$  typically less than  $E_0$  and with a corresponding section with area  $S_1$ , such that  $S_0/S_1$  typically ranges between 2 and 10, the extrusion, axial drawing, radial expansion and chopping steps being carried out continuously while moving so as to obtain caps that are both economic, easily heat shrinkable and with a stable axial dimension thereby avoiding any axial distortion, and particularly any axial distortion of the printout.

2. Method according to claim 1, in which the axial drawing step is delimited on the output side by a cooling zone in which a cooling means lowers the temperature of the axially drawn tube to a temperature  $T_1$ , the temperature  $T_1$  being chosen:

(a) to be fairly high so that it is equal to at least the glass transition temperature  $T_g$  or the melting temperature  $T_f$  of the thermoplastic material, so as to be able to use the subsequent radial expansion step,

(b) to be fairly low to interrupt the axial drawing step and thus to fix the diameter of the axially drawn tube to a typically predetermined diameter  $D_1$ .

3. Method according to claim 2, in which the temperature  $T_1$  is such that  $\Delta T$ , equal to  $T_0 - T_1$ , varies from  $30^\circ$  to  $150^\circ\text{C}$  and typically from  $45^\circ$  to  $100^\circ\text{C}$ .

4. Method according to either claim 2 or 3, in which the cooling means includes an external air or water projection, typically an annular projection.

5. Method according to any one of claims 2 to 4, in which the cooling means comprises a ring cooled with air or water.

6. Method according to claim 5, in which the ring includes a part with diameter  $D_1$  so as to form a calibration ring from which a tube with diameter  $D_1$  projects, typically axially drawn and cooled to temperature  $T_1$ .

7. Method according to any one of claims 2 to 6, in which the cooling means includes air or water projection inside the axially drawn tube, typically through a pipe passing through the die.

8. Method according to any one of claims 2 to 7, in which the radial expansion device supplied on the input side with the axially drawn tube at the temperature  $T_1$ , includes a radial expansion chamber provided with an inner wall with diameter  $D_2$  connected on the input side to an expansion area designed to change the diameter of the axially drawn tube from  $D_1$  to  $D_2$ .

9. Method according to claim 8, in which the radial expansion device includes an entry ring on the input side, typically with diameter  $D_1$ , so as to have an axially drawn tube with diameter  $D_1$  and a regular profile before the radial expansion.

10. Method according to claim 9, in which the entry ring forms an annular chamber typically a ring, with an inside area with inside diameter  $D_1$ , the inner surface comprising a

plurality of vacuum creation orifices, the annular chamber being put under a pressure  $P_a < P$  atmospheric, so as to force the axially drawn tube into contact with the inner surface.

11. Method according to any one of claims 1 to 10, in which the radial expansion is obtained either by keeping the inside of the tube under pressure, or by keeping the outside of the tube under negative pressure.

12. Method according to claim 11, in which the radial expansion is obtained by keeping the tube under a vacuum, the radial expansion device including a suction inside wall using vacuum creation holes such that the tube with diameter  $D_1$  is forced into contact with the inside wall of the expansion area and/or into contact with the inside wall, with inside diameter  $D_2$ , the temperature  $T_1$  being chosen to be as low as possible so as to obtain high heat shrinkage, but high enough to enable the radial expansion.

13. Method according to claim 12, in which the inside wall with diameter  $D_2$  is a tubular metallic part, typically a steel, aluminum, copper alloy part, for example such as a bronze or cupro-nickel alloy, the part possibly being a sintered part capable of allowing air to pass through, the inside wall possibly being surface treated, either to minimize friction forces between the inside wall and the tube, or to give a particular surface appearance to the tube.

14. Method according to any one of claims 1 to 13, in which the radial expansion step in the expansion area results in an increase of the diameter from  $D_1$  to  $D_2$  or  $\Delta D = D_2 - D_1$  equal to at least 10 mm, over a distance  $L_1$  less than 250 mm and typically less than 100 mm, such that the  $\Delta D/L_1$  ratio is as high as possible and typically more than 1/25, and thus the radial expansion includes a low or negligible axial expansion component.

15. Method according to any one of claims 1 to 14, in which the radial expansion step includes auxiliary cooling due to an auxiliary cooling means so as to have a radially expanded tube at the exit from the radial expansion device, at a temperature  $T_2$  typically between 10°C and 60°C and typically at ambient temperature, the auxiliary cooling means typically including cooling of the tubular metallic part or the inside wall with diameter  $D_2$ , the temperature  $T_2$  having to be fairly low so that the tube obtained at the exit from the radial expansion device can be drawn by the axial tension means without any risk of failure or elongation of the radially expanded tube with diameter  $D_2$ .

16. Method according to any one of claims 1 to 15, in which the diameter  $D_0$  of the die forming the extruded tube typically varies from 20 mm to 50 mm, and its slit width or thickness  $E_0$  typically varies from 0.5 mm to 3 mm, so as to have a flow of plastic material from the extruder typically varying from 10 kg to 100 kg of plastic material/hour.

17. Method according to any one of claims 1 to 16, in which the diameter  $D_1$  of the axially drawn tube typically varies from 5 to 20 mm, and its thickness  $E_1$  typically varies from 0.2 mm to 0.6 mm, with a  $D_1/D_0$  ratio equal to not more than 0.6, and with an  $E_1/E_0$  ratio equal to not more than 0.6.

18. Method according to any one of claims 1 to 17, in which the diameter  $D_2$  of the radially expanded tube typically varies from 20 mm to 50 mm and its thickness  $E_2$  varies from 0.05 mm to 0.35 mm, and typically from 0.075 mm to 0.15 mm, with a  $D_2/D_1$  ratio equal to not more than 2 and with an  $E_2/E_1$  ratio equal to not more than 0.6.

19. Method according to any one of claims 2 to 18, in which the radial expansion device is placed at a distance  $L$  from the die, the radial expansion device typically being free to move along the axial direction, the distance  $L$  being chosen particularly as a function of the plastic material, so as to obtain a sufficient degree of axial drawing and so as to obtain sufficient cooling of the axially drawn tube.

20. Method according to claim 19, in which the cooling means is placed at a distance  $L_0 < L$  from the die, the distance  $L_0$  being chosen particularly as a function of the plastic material so as to obtain sufficient axial drawing, the cooling means typically being free to move along the axial direction so as to regulate the diameter  $D_1$  at the input to the radial expansion device by a displacement  $\Delta L_0$  of the cooling means around the distance  $L_0$ .

21. Method according to claim 20, in which the radial expansion device includes the annular chamber under a vacuum at the pressure  $P_a$ , and in which the displacement  $\Delta L_0$  is controlled by the pressure  $P_a$ , any increase in pressure  $P_a$  introducing a negative difference  $\Delta D_1$  in diameter with respect to the diameter  $D_1$  for the axially drawn tube, the negative difference  $\Delta D_1$  being corrected by a negative displacement  $\Delta L_0$  so as to increase the diameter of the axially drawn tube by  $\Delta D_1$ .

22. Method according to either claim 20 or 21, in which the displacement  $\Delta L_0$  is controlled by the axial tension force  $F_t$  applied by the tension means, any increase or positive difference  $\Delta F_t$  in the force  $F_t$  typically implying a positive difference  $\Delta D_1$  in the diameter of the tube, the axially drawn tube then having a larger diameter than the entry diameter into the radial expansion device, the positive difference  $\Delta F_t$  possibly being corrected by a positive displacement  $\Delta L_0$  so as to reduce the diameter of the axially drawn tube by  $\Delta D_1$ .

23. Method according to any one of claims 1 to 22, in which the thermoplastic material is composed of or comprises at least one first thermoplastic material with a glass transition temperature  $T_g$  equal to at least  $40^\circ\text{C}$ , and typically chosen from among PET, PVC, PS, PMMA, or a mix of these materials, or copolymers of PET, PVC, PS, PMMA.

24. Method according to any one of claims 1 to 23, in which the thermoplastic material includes or is composed of at least one second thermoplastic material with a glass transition temperature  $T_g$  less than  $50^\circ\text{C}$  and typically less than  $10^\circ\text{C}$ , and typically chosen from among polyolefins such as PE, PP, PB or from among ethylene copolymers such as EVA, EMA, EAA, ethylene and propylene copolymers or from among thermoplastic elastomers such as SIS, SEBS or a mix of these elastomers.

25. Method according to either claim 23 or 24, in which the thermoplastic material includes a mix of the first thermoplastic material and the second thermoplastic material, the mix including at least 50% by volume of the first thermoplastic material, and 10 to 50% by volume of the second thermoplastic material, so as to obtain caps with a range of textures and flexibility depending on the relative content of the first and second thermoplastic materials.

26. Method according to either claim 23 or 34, in which the thermoplastic material forms or comprises a multi-layer material, the multi-layer material comprising a first layer composed of the first thermoplastic material and a second layer composed of the second thermoplastic material, the multi-layer material possibly including an internal adhesive layer.

27. Method according to any one of claims 1 to 26, in which all or some of the thermoplastic material contains a micronised filler typically chosen from among talc, calcium

carbonate, barium sulphate, titanium oxide, organic or mineral pigments, nanoparticle clays, so as to color the thermoplastic material.

28. Method according to any one of claims 1 to 27 in which the tube portion in the chopping step c) is a so-called "short" tube portion, the appropriate length of the tube portion typically being chosen to be approximately the height H of the cap, in this case, in the forming step d), a disc with a flat or curved edge is supplied that will form the head of the cap, and in which the disc is assembled to the skirt blank, typically by heat sealing using a cavity cooperating with the mandrel, cooperation of the cavity with the mandrel possibly shaping the disc or putting it in relief.

29. Method according to claim 28, in which the disc is obtained by cutting a sheet material, possibly transparent, made of a material chosen from among plastics, metal strips or sheets, paper or cardboard or multi-layer assemblies of these materials, the disc possibly comprising any type of system particularly to identify the cap, to monitor and assure traceability of packaged products, and to form an anti-fraud and anti-theft means.

30. Method according to either claim 28 or 29, in which the disc is an excise disc.

31. Method according to any one of claims 28 to 30, in which the disc is replaced by an insert comprising a head and possibly a skirt, the insert being placed at the upper end of the conformation mandrel, typically before heat shrinking of the tube portion, so as to assemble the insert to the heat-shrunk skirt blank, possibly using an adhesive or heat-sealing layer.

32. Method according to claim 31, in which the insert comprises a thread and is provided with a sealing means so as to form a closing cap.

33. Method according to any one of claims 1 to 27 in which the tube portion in the chopping step c) is a so-called "long" tube portion, the appropriate length being chosen to be greater than the height of the cap, the tube portion comprising a lower part designed to form the skirt of the cap, and an upper part designed to form the head of the cap, the head being formed by compression or moulding of the upper part between a die and a head of the mandrel.

34. Method according to claim 33 in which an auxiliary part typically forming a pattern, a décor or an excise means, is introduced into the cavity before the compression, so as to simultaneously form the head and to assemble the auxiliary part to the head.

35. Method according to any one of claims 1 to 34, in which the printing is formed on the tube portion, and/or on the skirt, and/or on the head, and/or on the heat-shrunk skirt blank, either before or after assembling or forming the head of the cap.

36. Method according to claim 35, in which inks that can be cross-linked by radiation, and typically UV inks, are used for the printing such that the printing is typically formed at a temperature below the temperature at which the cap shrinks.

37. Method according to either claim 35 or 36, in which the printing is formed by using an ink jet print device or by a transfer comprising a plurality of N printing nozzles in parallel along the axial direction or height H, the plurality including a density of nozzles equal to at least 1 nozzle per mm, the device typically being controlled by a computer provided with digital storage means for the printed patterns to be reproduced on the cap so as to be able to print several different patterns simultaneously, to be able to change the printed pattern immediately when necessary and thus to print possibly very short series of caps.

38. Method according to any one of claims 1 to 37, in which all or some of the thermoplastic material is colored in-depth.

39. Method according to any one of claims 26 to 38 in which the multi-layer material includes an outside layer made of a plastic material, typically polar or with a high surface energy so that it can be printed and that leads to a décor bonding to the outside layer.

40. Method according to any one of claims 1 to 39, in which the skirt comprises an easy opening means typically including two lines of weakness spaced apart from each other to form an opening tab provided with a manual gripping end.

41. Method according to any one of claims 1 to 40, in which the axial tension means includes two driving rollers or two belt type pullers.

42. Heat shrinkable outer closing caps, obtained by the method according to any one of claims 1 to 41, and typically intended for outer closing of previously closed bottle necks, with height H between 20 and 100 mm and with a skirt thickness between 0.05 mm and 0.5 mm, in which the thermoplastic material includes a mix of:

- a first thermoplastic material with a glass transition temperature  $T_g$  equal to at least 40°C and typically chosen from among PET, PVC, PS, PMMA or a mix or them or their copolymers,

- and a second thermoplastic material with a glass transition temperature  $T_g$  less than 50°C.

43. Heat shrinkable closing caps obtained using the method according to either claim 31 or 32, and claims 35 to 41, and typically intended for outer closing of previously closed bottle necks, with height H between 20 and 100 mm and with a skirt thickness between 0.05 mm and 0.5 mm, for the lower part of the skirt not assembled to the insert, in which the thermoplastic material includes a mix of:

- a first thermoplastic material with a glass transition temperature  $T_g$  equal to at least 40°C,

- and a second thermoplastic material with a glass transition temperature  $T_g$  less than 50°C.

44. Heat shrinkable caps obtained using the method according to any one of claims 1 to 30 and 33 to 41, and intended particularly for outer closing of previously closed bottle necks of sparkling wines or pressurized carbonated drinks, obtained with a height H of between 60 and 200 mm and with a skirt thickness of between 0.1 mm and 1.0 mm, in which the thermoplastic material includes a mix of:

- a first thermoplastic material with a glass transition temperature  $T_g$  equal to at least 40°C and typically chosen from among PET, PVC, PS, PMMA or a mix or them or their copolymers,

- and a second thermoplastic material with a glass transition temperature  $T_g$  less than 50°C.

45. Caps with a skirt made of heat shrinkable thermoplastic material, and with a head possibly made with the heat shrinkable thermoplastic material, according to any one of claims 42

to 44, in which the first thermoplastic material has a glass transition temperature  $T_g$  equal to at least 40°C and is chosen from among PET, PVC, PS, PMMA or a mix or them or their copolymers, and in which the second thermoplastic material has a glass transition temperature  $T_g$  less than 10°C, and is typically chosen from among polyolefins such as PE, PP, PB or from among ethylene copolymers such as EVA, EMA, EAA or from among ethylene and propylene copolymers, or from among thermoplastic elastomers such as SIS, SEBS or a mix of them.

46. Caps according to claim 45, in which the mix includes at least 50% by volume of the first thermoplastic material and from 10 to 50% by volume of the second thermoplastic material.

47. Caps according to any one of claims 42 to 46, comprising a layer of reactivatable thermoadhesive coating on the inside, typically a "hot-melt" layer so as to fix all or part of the caps on the necks.

48. Stacks of caps, formed by a stack of caps according to any one of claims 42 to 47, the caps being tapered and typically printed on their outside surface.